

Measuring physical properties and heterogeneous chemistry of single airborne particles concurrently using optical trapping–Raman spectroscopy (OT–RS)

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Our current understanding of airborne particles, for example, aerosols, ice nuclei, etc., is mainly based on measurements of particle ensembles, and their fundamental physical and chemical properties are not yet completely clear. Measuring a single particle can reveal the fundamental properties of the target sample as well as view the dynamic evolving processes. Among various single-particle techniques for airborne particles, optical trapping has unique advantages: no interferences from substrates or liquid solution, no mechanical contacts, no requirement of charge, and so on. With recent developments, the optical trapping technique can trap both transparent and absorbing particles in air using a universal optical trap (UOT) based on counter-propagating hollow beams. A wide variety of particles ranging from spherical silica microspheres and droplets to irregularly shaped carbon nanotubes and bioaerosols can be stably trapped in the UOT. Both physical and chemical properties can be resolved and monitored by a microscopy imaging system and Raman spectroscopy (RS). We demonstrate the analytical capabilities of the OT-RS system in three different scenarios, 1) unchanged, 2) partially degraded, and 3) fragmented particles in the optical trap. The evolution processes of different cases are also temporally resolved. This new technique enables the studies of single particle's microphysical properties as well as heterogeneous chemistry. Furthermore, the effective fluorescence bleaching phenomenon is observed in the trapped particle, which facilitates Raman spectroscopic studies of single biological particles without fluorescence interferences.

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